Relationship of Parental Smoking and Gas Cooking to Respiratory Disease in Children*

Edem E. Ekuo, M.D., M.P.H.; Miles M. Weinberger, M.D., F.C.C.P.; Peter A. Lachenbruch, Ph.D.; and William H. Huntley, R.R.T.

In a survey of 1,355 children six to 12 years of age, the risk of hospitalization for respiratory illness among children before age two years was increased when gas was used for cooking at home ($p < 0.001$) or at least one of the parents smoked ($p < 0.02$). The occurrence of cough with colds in children also was significantly increased when one or both parents smoked ($p < 0.001$). Small but significant increases ($p < .05$) in the mean values of forced expiratory volume at one second, the flow rate at 75 percent of the forced vital capacity, and the forced expiratory flow rate from 25 percent to 75 percent of the vital capacity (FEF25-75) were seen after administering inhaled isoproterenol to children whose parents smoked (n = 94) but not among children whose parents did not smoke (n = 89); this was not seen in association with gas cooking. Thus, exposure of children during the first two years of life to gas cooking or cigarette smoking appears to be associated with an increased risk of hospitalization for respiratory illness, and cigarette smoking appears to be associated with a more consistent response to inhaled bronchodilator among six- to 12-year-old children with no other history of chronic respiratory illness.

Parental smoking has been shown to be related to increased risk of respiratory illness in children during the first year of life,[1,2] and to an increased risk of morning cough, respiratory infections, and breathlessness among older children.[1-3] Specifically, an increased incidence of pneumonia and bronchitis with consequent hospitalizations has been reported among infants whose parents smoked compared to children whose parents did not smoke.[1] Parental smoking also has been reported to increase the risk of persistent wheeze[4] and symptomatic asthma.[3] In a study of British secondary schoolchildren that showed early morning cough to be more commonly reported by children who smoked, the effect on these smoking children of parental smoking appeared to be additive.[4] A decrease in pulmonary function measurements also has been noted in nonsmoking children whose parents smoked.[5,6]

For editorial comment see page 651

An association has been similarly shown between respiratory illness in children and gas cooking, apparently from increased levels of nitrogen dioxide and nitric oxide in the homes with gas stoves.[3,7] In addition, pulmonary function measurements performed in school age children were found to be lower in association with the use of gas stoves in the home.[7,8]

The current study was designed to further examine the relationship of parental smoking and gas cooking on the occurrence of respiratory illness and symptoms in children from a midwestern university community. Additionally, we examined the relationship between these environmental exposures and pulmonary functions.

Methods

Subjects

Children, ages 6 to 12, who attended primary school in the Iowa City School District were contacted after permission was obtained from school administrators. The school district serves a university community. The children were therefore generally from middle and upper social classes. Participating schools included approximately 87 percent of the 2,062 children six to 12 years of age enrolled in the school district. Children from the participating schools were sent home with a letter explaining to parents the purpose of the studies, the information we were interested in collecting and why. The parents were requested to complete a modification of the questionnaire developed by the American Thoracic Society (ATS) for the Division of Lung Disease (DLD) of the National Heart, Lung, and Blood Institute (the ATS-DLD questionnaire)[9] and to return it to us in a stamped, self-addressed envelope. (A copy of the modified questionnaire is available on request from the authors.) Two weeks following the initial distribution of the questionnaires to the parents, another letter was sent as a reminder to parents who had failed to return a completed questionnaire.

In order to determine if nonrespondent parents and their children differed significantly in certain characteristics from those parents who had completed the questionnaires about their children, 200 nonrespondent parents were randomly selected and contacted by telephone by a trained research assistant four weeks after the questionnaires were initially sent to the parents. The parents were each read the part of the questionnaire that related most directly to cigarette smoking and respiratory illness. To ensure that the questions were answered accurately, these pertinent questions from the questionnaire were read aloud exactly as printed and without any elaboration by the research assistant.

Pulmonary Function Measurement

Pulmonary function measurements were obtained from 89 chil-

*From the Divisions of Ambulatory and Community Pediatrics and Pediatric Allergy and Pulmonary Disease, Department of Pediatrics, and the Department of Preventive and Environmental Medicine, The University of Iowa Medical School, Iowa City.

This work was supported in part by Grant No. HD159 from the Clinical Research Center, by NIH Grant HOD AI06151-01, by Cystic Fibrosis Foundation Grant C 521 A, and by the Johnson County (IA) Lung Association.

Manuscript received December 6, 1982; revision accepted June 29.

dren (47 girls and 41 boys) whose parents did not smoke and 94 children (52 girls and 42 boys) whose parents smoked. These children were randomly selected using tables of random numbers from the children for whom complete information was obtained using the questionnaire. All parents were requested to indicate their consent for pulmonary function studies to be obtained from their children, after we had provided a full written explanation of the reasons for obtaining the measurements and the procedures the child would follow during pulmonary function testing. Consent was obtained from 411 (83.6 percent) of the 484 children whose parents did not smoke and 596 (91.1 percent) of the 654 children whose parents smoked. When parental smoking was kept constant, the proportions of children who had cough with cold, cough apart from colds, or phlegm with or apart from colds were not significantly different for consenting parents compared to nonconsenting parents. We therefore felt that our sampling procedure produced a representative population of children.

Children were excluded if there was a history of recurrent respiratory illness or if there was any history of upper or lower respiratory infection during the prior six months. Spirometry was measured with a Jones Pulmonor waterless respirometer. Calculations of the parameters measured were done by the Jones Datamatic Computer with daily calibration. Lung volumes were measured by use of a plethysmograph (model 2100B Cardiopulmonary Instruments) using a 3 L/second Fleisch temperature-controlled pneumotach, with a flow accuracy of ± 1 percent of full scale.

Each child was instructed in the measurement maneuver and was in an upright sitting position. Each test was repeated three to five times, and the best effort was taken. Flow rates and lung volumes were measured before and five minutes subsequent to 1.25 mg inhaled isoproterenol diluted with 2 ml normal saline solution and administered by an open nebulizer.

Analysis of Data

Discrete multivariate analysis was used to study the interactions among factors.[8,9] In this analysis, maternal and paternal smoking and gas cooking were treated as independent factors, while the frequencies of various respiratory symptoms or illness were the dependent variables. The reported prevalence of respiratory symptoms or illnesses were stratified by parental smoking (mother alone, father alone, both parents, either or both parents, neither parent smokes) and by cooking fuel use. Odds ratio was calculated for each interaction effect. Odds ratios greater than one indicated that the variable had a higher risk for the children and conversely odds ratios of less than one indicated lower risk. A chi-square analysis was used to examine the significance of the odds ratio.

Regression lines were fitted to each of the pulmonary function measurements using the Statistical Analysis System (SAS) using the stepwise procedure.[10] The variables entered in the equation were age in years, sex, weight (kg), and standing height (cm). Lines were fitted separately for children from smoking and nonsmoking environments, as well as for values obtained by pooling these two groups. F-tests were performed as described by Neter and Wasserman[11] to compare the fit of the lines obtained for values for children from the two environments and for the pooled data. Paired *t*-tests were used to compare the prebronchodilator and postbronchodilator pulmonary functions.

Results

Completed questionnaires were obtained for 1,355 children, or 65.7 percent of the children six to 12 years of age in the school district. Of the 1,355 completed questionnaires, data on parental smoking history was complete for 1,138 (84 percent) of the children. In the remaining 217 questionnaires, either maternal or paternal or both smoking histories were unrecorded or incompletely recorded. The proportion of children with incomplete or no parental smoking history who had cough with or apart from colds, congestion or bringing up phlegm, or had chronic lung diseases was not statistically significantly different from the proportion of children with parental smoking histories who had these symptoms. These questionnaires were eliminated in subsequent analysis. Forty-nine percent of these children were males, and 51 percent were females. Five percent of the children had established diagnoses of chronic respiratory diseases. Two had cystic fibrosis, one had pulmonary tuberculosis, two had diagnoses of chronic bronchitis, and 49 had asthma. When we compared the 200 randomly selected nonrespondent families to our study population, we found no statistically significant differences in the proportion of parents who smoked at home. The proportions of children who had cough with colds, cough apart from colds, or who had congestion or bringing up phlegm with or apart from colds were not significantly different among the two groups.

Fifteen percent of the parents completing the questionnaire indicated they had bronchitis, emphysema, asthma, or other chronic respiratory condition. We found no relationship between the report of chronic respiratory illnesses in parents and the reported prevalence in children of symptoms of cough with colds,

Table 1—*Proportion of Children with Cough with Colds or Hospitalized for Chest Problems Before Age 2 Years, by History of Parental Smoking and Home Cooking Fuel Used*

Home Cooking Fuel	Parental Smoking History (Yes = Parent Smokes)		Percentage of Children Affected (Total Number of Children in the Group)	
	Father	Mother	Cough With Colds	Hospitalization For Chest Illnesses
Gas	No	No	32.8 (137)	5.1 (138)
Gas	No	Yes	35.7 (28)	7.1 (28)
Gas	Yes	No	35.6 (101)	8.0 (100)
Gas	Yes	Yes	30.6 (111)	9.8 (112)
Electricity	No	No	28.9 (343)	2.1 (341)
Electricity	No	Yes	37.7 (69)	8.8 (68)
Electricity	Yes	No	37.7 (69)	5.6 (178)
Electricity	Yes	Yes	44.5 (171)	1.2 (172)

Table 2—*Association of Parental Smoking and Gas Cooking with Hospitalization of Children Before Age 2 Years for Respiratory Illnesses*

Independent Variables	No. of Children Hospitalized for Chest Illnesses		Odds Ratio	SE	p-Value
Fuel used for home cooking	Yes	No			
Gas	28	350	2.4	0.684	0.001
Electricity	25	736	1.0	...	...
Parental smoking					
Father alone smokes	18	260	2.3	0.856	0.022
Mother alone smokes	8	90	2.9	1.279	0.026
Father and mother smoke	13	271	1.6	0.856	0.21
Either or both parents smoke	39	621	2.1	0.666	0.017
Neither parent smokes	14	465	1.0	...	...

enough apart from cold, or bringing of phlegm with or apart from colds. Of the 1,138 children, 31 percent lived in homes where gas was used for cooking, and 69 percent lived in homes where electricity was used for cooking. There was a significant association between parental smoking and the use of gas for cooking. Fathers smoked in 224 (56.4 percent) of the 397 homes where gas was used for cooking, compared to 366 (46.6 percent) of the 786 homes in which electricity was used for cooking ($\chi^2 = 10.28$, $p<0.001$). Similarly, mothers smoked in 180 (40.8 percent) of the 441 homes in which gas was used for cooking, compared to 292 (33.7 percent) of the 866 homes in which electricity was used for cooking ($\chi^2 = 6.33$, $p<0.05$). The proportion of children with chronic respiratory symptoms by parental smoking and use of cooking fuel are shown in Table 1.

The use of gas for cooking was associated with an increased risk of hospitalization of the children before age two years because of chest colds and other respiratory illnesses (odds ratio = 2.4) independent of parental smoking (Table 2). Any parental smoking also increased the odds ratio. When both parents smoked in a household in which gas was used for cooking, the odds ratio was 9.25 ($p = 0.0006$). The use of gas for cooking was not associated with increased risk of occurrence of cough with colds in the children. However, parental smoking increased the risk of occurrence of these symptoms (Table 3). Other than the possibility of wheezing and whistling sounds in the chest with colds, none of the dependent variables in Table 4 was significantly associated with parental smoking and/or use of gas for cooking. Also, the frequency of occurrence of ear infections in the children between ages 0 to two years, or two to five years, or the occurrence of wheezing with exercise was not found to be associated with parental smoking or use of gas for cooking.

The mean standing height of 144.2 cm and weight of 37.8 kg for children whose parents smoked was not significantly different from the mean standing height of 145.6 cm and weight of 38.7 kg for children whose parents did not smoke. Mean values for initial measurements of pulmonary function before the inhaled isoproterenol did not differ significantly between children from smoking and non-smoking families. Significant differences in mean values were not seen after bronchodilator inhalation in the children from non-smoking families, but were apparent among children from smoking families for the measurements of FEF75, FEV_1, and FEF25-75 (Table 5). The mean values of the measurements of lung volumes for the two groups of children were not statistically different. Because 28 *t*-tests were performed for these analyses, adjustment was made by accepting only *t*-tests with p

Table 3—*Association of Parental Smoking and Gas Cooking with Occurrence of Cough with Colds in Children*

Independent Variables	No. of Children with Symptoms of Coughs with Colds		Odds Ratio	SE	p-Value
Fuel used for home cooking	Yes	No			
Gas	125	252	0.9	0.123	0.55
Electricity	266	495	1.0	...	...
Parental smoking					
Father alone smokes	100	177	1.4	0.228	0.023
Mother alone smokes	36	61	1.5	0.348	0.084
Father and mother smoke	111	173	1.6	0.235	0.012
Either or both parents smoke	247	411	1.5	0.194	0.001
Neither parent smokes	144	306	1.0	...	...

Table 4—*Relationship of Parental Smoking and Cooking Gas with Occurrence of Respiratory Symptoms in Children*

Independent Variable	No. of Children with Respiratory Symptoms		Odds Ratio	SE	p-Value
	Yes	No			
1. Chest congestion and phlegm with colds					
Gas	70	307	1.1	0.188	0.41
Electricity	126	633	1.0	...	...
Father alone smokes	46	230	1.0	0.213	0.82
Mother alone smokes	19	78	1.3	0.363	0.40
Father and mother smoke	54	229	1.2	0.383	0.28
Either or both parents smoke	119	537	1.2	0.186	0.35
Neither parent smokes	77	403	1.0	...	...
2. Chest congestion and phlegm apart from cold					
Gas	17	345	1.0	0.302	0.99
Electricity	35	708	1.0	...	...
Father alone smokes	12	258	0.9	0.345	0.86
Mother alone smokes	7	87	1.6	0.730	0.30
Father and mother smoke	11	264	0.8	0.317	0.64
Either or both parents smoke	30	609	1.0	0.286	0.98
Neither parent smokes	22	444	1.0	...	...
3. Wheezing and whistling sounds in chests with colds					
Gas	104	273	1.0	0.154	0.56
Electricity	198	564	1.0	...	...
Father alone smokes	74	202	1.2	0.210	0.27
Mother alone smokes	30	67	1.5	0.362	0.12
Father and mother smoke	86	198	1.4	0.241	0.03
Either or both parents smoke	190	467	1.3	0.185	0.03
Neither parent smokes	112	370	1.0	...	...
4. Wheezing and whistling sound in chest apart from colds					
Gas	29	326	0.9	0.222	0.80
Electricity	61	647	0.1	...	...
Father alone smokes	24	235	1.2	0.329	0.52
Mother alone smokes	14	73	2.2	0.761	0.02
Father and mother smoke	16	244	0.6	0.239	0.39
Either or both parents smoke	54	552	1.1	0.257	0.55
Neither parent smokes	36	421	1.0	...	...
5. Attacks of wheezing with shortness of breath					
Gas	30	346	0.7	0.158	0.12
Electricity	83	679	1.0	...	...
Father alone smokes	26	251	0.8	0.211	0.48
Mother alone smokes	12	85	1.1	0.389	0.70
Father and mother smoke	22	261	0.7	0.181	0.14
Either or both parents smoke	60	597	0.8	0.161	0.29
Neither parent smokes	53	425	1.0	...	...

values of <0.002 as significantly different at a 0.05 confidence level (0.05 ÷ 28 = 0.002) The mean percentage changes in the pulmonary function measurements (calculated as the differences between the postvalue and prevalue divided by the prevalues for each patient), however, did not differ significantly between the two groups of children (using an unpaired *t*-test).

Discussion

Respiratory symptoms and illnesses occur frequently, particularly in the temperate regions of the worlds in preschool and school-age children. Only recently has it been appreciated that parental smoking at home may be associated with an increased risk of occurrence of respiratory symptoms in children. A higher rate of hospitalization of the children before age two years for chest illnesses (bronchitis, pneumonia, etc) was associated with both parental smoking and gas cooking. A significant increase in pulmonary function after an inhaled bronchodilator among children of

Table 5—*Flow Rates of Children Before and After Inhaled Isoproterenol*

Variables	Children of Smoking Parents			Children of Nonsmoking Parents		
	Mean (SE) Measurements of Flow Rates and Lung Volumes			Mean (SE) Measurements of Flow Rates and Lung Volumes		
	Preisoproterenol	Postisoproterenol	p*	Preisoproterenol	Postisoproterenol	p*
PEFR	5.11 (0.13)	4.97 (0.13)	0.11	5.10 (0.13)	5.05 (0.12)	0.42
FEF25	4.18 (0.12)	4.15 (0.12)	0.71	4.34 (0.11)	4.23 (0.1)	0.11
FEF50	3.22 (0.09)	3.35 (0.09)	0.02	3.25 (0.09)	3.36 (0.09)	0.07
FEF75	1.52 (0.05)	1.76 (0.07)	0.0001†	1.56 (0.06)	1.69 (0.07)	0.11
FEV_1	2.23 (0.05)	2.27 (0.05)	0.0002†	2.21 (0.05)	2.23 (0.06)	0.34
FEV_3	2.52 (0.06)	2.52 (0.06)	0.48	2.47 (0.06)	2.50 (0.07)	0.17
FEF25-75	2.60 (0.08)	2.82 (0.08)	0.0001†	2.60 (0.07)	2.78 (0.09)	0.03
FVC	2.55 (0.06)	2.57 (0.06)	0.18	2.51 (0.07)	2.53 (0.07)	0.13

*Paired *t*-test comparing initial pulmonary function measurements and postbronchodilator values.
†Significant at 0.05 level after adjusting for the performance of 28 *t*-tests.

smoking parents is an interesting additional observation perhaps consistent with previous reports of increased bronchial reactivity in cigarette smokers with normal lung function[9] and an association between symptomatic asthma in children and parental smoking.[10]

Parental smoking may be associated with different types of respiratory illnesses in infancy compared to the school age. Fergusson et al[1] found an increased risk of infantile lower respiratory illnesses in the last eight months of the first year of the infant's life to be associated with maternal but not paternal smoking. Similarly, Colley et al[3] found that infantile pneumonia was more common when both parents smoked than when neither parent smoked. The risk was intermediate when only one parent smoked. These results are consistent with our findings that hospitalization of children in the first two years of life for bronchitis and pneumonia was associated with parental smoking. However, Fergusson et al[1] did not study the association of parental smoking and use of gas for cooking on respiratory infection rates. Their study is different from ours also, in that they studied respiratory infection rate between four and 12 months of life. Their study was prospective-retrospective in design, and therefore, parental recall may have been more reliable than in our study. In the first year of life, an infant is likely to spend proportionately more time with the mother than the father. Thus, the age of the child at the time of the administration of the respiratory questionnaire may have been an important factor in the finding that maternal but not paternal smoking was associated with respiratory illness in the child.

Weiss et al[4] reported a dose response between prevalence rate of symptoms of persistent wheezing, cough, and phlegm in children and parental smoking. The rate of occurrence of symptoms in children was highest when both parents smoked, intermediate when either parent smoked, and lowest when no parent smoked. However, the authors also found a strong association between the occurrence rate of these symptoms in the children and the prevalence rate for such symptoms in the parents. We found a significant association between parental smoking and the prevalence of cough with colds in the children. However, we did not find any association between parental smoking or the use of gas cooking and the reported incidence of cough apart from colds and chest congestion and bringing up phlegm with or apart from colds. In a study of children whose ages were similar to the children in our population, however, Colley[3] found an association between parental smoking and the occurrence of cough during the day or at night in winter in the children. He also found an association between parental smoking and bringing up "any phlegm from the chest first thing in the morning in winter" by the children. The lack of association between these variables and parental smoking in our study may be attributable to the phrasing of the questions in the ATS-DLD questionnaire, where "in the morning" was not specifically mentioned, and where phlegm production was sought in association with chest colds rather than "in winter." Slight changes in the phrasing of questions can result in substantial differences in the type of responses one obtains.[20,21]

Flory et al[5] showed an association between the levels of NO_2 in kitchens and bedrooms of the homes, and the prevalence of respiratory illness in primary schoolchildren. This association was independent of the children's age, sex, social class, and the number of cigarettes smoked at home. In another study, children six to 11 years old from households with gas stoves had a history of more frequent respiratory illnesses before age two years compared to children from homes where gas was not used for cooking.[11] In a study of schoolchildren in England and Scotland, a reported incidence of coughs, colds going to the chest, and bronchitis in children from homes using gas for cooking

was significantly higher than for children from homes where electricity was used.[20] Melia et al[18,20] demonstrated that the association between respiratory illness and gas cooking tended to disappear as the children grew older.

The nature of the association of respiratory symptoms in children and gas cooking in the home is yet unclear. Two oxides of nitrogen, nitric oxide (NO) and nitrogen dioxide (NO_2), are produced in varying concentrations in homes with gas stoves.[20-22] It has been observed that acute exposure of man and animals to high levels of nitrogen dioxide (NO_2) can cause pulmonary edema and death.[23]

A significant reduction in FEF25-75 values was observed in children who smoked, as well as in children whose parents smoked but who were nonsmokers themselves.[18] At least one group of investigators has found no association between parental smoking and lung function measurements of the children.[17] In these studies, the children did not receive an inhaled bronchodilator drug. Inhaled bronchodilator medication was administered to children in our study, and we observed statistically significant differences in the mean values of FEF75, FEV_1, and FEF25-75 for children whose parents smoked compared to those whose parents did not smoke. The clinical importance of such observed differences in the absolute values of pulmonary function measurements is, however, unclear.

In a recent study of children six to 11 years old from households with gas stoves, small but significant differences were found in FEV_1 and FVC corrected for height, compared to children from homes where gas was not used for cooking.[24] These families tended to be poorer and were in the lower socioeconomic class. Flory et al[5] found no significant relationship between lung function measurements and concentrations of NO_2 in either kitchen or bedroom. Lung function measurements of peak expiratory flow rates (PEFR) and FEF25-75 for children from homes with gas stoves were not significantly higher than measurements for children from homes with electric stoves. Hasselblad et al,[12] however, found pulmonary function suggestively decreased among nine- to 13-year-old girls in homes with gas stoves and not among younger children.

Based on the findings of this report and from previously published findings, one is led to conclude that parental smoking is associated with a risk of certain respiratory illnesses and symptoms among children living in the same environment. An independent but similar effect is suggested for gas cooking. Children from homes where parents smoke had increased reactivity of airways after bronchodilator therapy, but it is not known if these changes persist or have clinical consequences.

References

1 Colley JRT, Holland WW, Corkhill RT. Influence of passive smoking and parental phlegm on pneumonia and bronchitis in early childhood. Lancet 1974; 2:1031-34

2 Harlap S, Davies AM. Infant admissions to hospital and maternal smoking. Lancet 1974; 1:529-32

3 Fergusson DM, Horwood LJ, Shannon FT. Parental smoking and respiratory illness in infancy. Arch Dis Child 1980; 55:358-61

4 Bland M, Bewley BR, Pollard V, Banks MH. Effect of children's and parents' smoking on respiratory symptoms. Arch Dis Child 1978; 53:100-105

5 Florey CV, Melia RJW, Chinn S, Goldstein BD, Brooks ACF, John HH, et al. The relationship between respiratory illness in primary schoolchildren and the use of gas for cooking. III. Nitrogen dioxide, respiratory illness and lung infection. Int J Epidemiol 1979; 8:347-53

6 Melia RJW, Florey CV, Chinn S. The relation between respiratory illness in primary schoolchildren and the use of gas for cooking. I. Results from a national survey. Int J Epidemiol 1979; 8:333-38

7 Colley JRT. Respiratory symptoms in children and parental smoking and phlegm production. Br Med J 1974; 2:201-04

8 Cameron P, Kostin JS, Zaks JM, Wolfe JH, Tighe G, Odlett B, et al. The health of smokers' and nonsmokers' children. J Allerg 1969; 43:336-41

9 Weiss ST, Tager IB, Speizer FE, Rosner B. Persistent wheeze: its relation to respiratory illness, cigarette smoking, and level of pulmonary function in a population sample of children. Am Rev Respir Dis 1980; 122:697-707

10 Gortmaker SL, Walker DK, Jacobs FH, Ruch-Ross H. Parental smoking and the risk of childhood asthma. Am J Public Health 1982; 72:574-79

11 Tager IB, Weiss ST, Rosner B, Speizer FE. Effect of parental cigarette smoking on the pulmonary function of children. Am J Epidemiol 1979; 110:15-26

12 Hasselblad V, Humble CG, Graham MG, Anderson HS. Indoor environmental determinants of lung function in children. Am Rev Respir Dis 1981; 123:479-85

13 Speizer FE, Ferris B, Bishop YMM, Spengler J. Respiratory disease rates and pulmonary function in children associated with NO_2 exposure. Am Rev Respir Dis 1980; 121:3-10

14 Ferris BG. Epidemiology standardization project. Am Rev Respir Dis 1978; 118:1-120

15 Bishop YMM, Fienberg S, Holland P. Discrete multivariate analysis. Cambridge:MIT Press, 1975

16 Dixon WJ. BMDP. Statistical software. 1981. Los Angeles: University of California Press, 1981

17 Barr AJ, Goodnight JH, Sall JP, Stepwise procedures. In: Helwig JT, Council CA, eds. SAS user's guide, 1979 edition. Raleigh, NC: SAS Institute Inc, 1979:391-96

18 Neter J, Wasserman W. Applied linear statistical models. Homewood, IL: Richard D. Irwin, Inc, 1974:87-89

19 Gerrard JW, Cockcroft DW, Mink JT, Cotton DJ, Pasnawala R, Dosman JA. Increased nonspecific bronchial reactivity in cigarette smokers with normal lung function. Am Rev Respir Dis 1980; 122:577-81

20 Comstock GW, Tockman MS, Helsing KJ, Hennessy KM. Standardized respiratory questionnaires, comparison of the old with the new. Am Rev Respir Dis 1979; 119:45-53

21 Helsing KJ, Comstock GW, Speizer FE, Ferris BG, Lebowitz D, Tockman MS, et al. Comparison of three standardized questionnaires on respiratory symptoms. Am Rev Respir Dis 1979; 120:1221-31

22 Melia RJW, Florey CV, Altman DG, Swan AV. Association between gas cooking and respiratory disease in children. Br Med J 1977; 2:149-52

23 Melia RJW, Florey CV, Darby SC, Palmes ED, Goldstein BD. Differences in NO_2 levels in kitchens with gas or electric cookers. Atmos Environ 1978; 12:1379-81
24 Cote WA, Wade WA, Yocum JE. A study of indoor air quality. Washington, DC: US Government Printing Office 1974 (United States Environmental Protection Agency Publication No. EPA 650/4-74-042)
25 Goldstein BD, Melia RJW, Chinn S, Florey CV, Clark D, John HH. The relation between respiratory illness in primary schoolchildren and the use of gas for cooking. II. Factors affecting nitrogen dioxide levels in the home. Int J Epidemiol 1979; 8:339-45
26 US Environmental Protection Agency. Scientific and Technical Data Base for Criteria and Hazardous Pollutants, 1975 ERC/RTP Review EPA Publications No. EPA-600/1-76-023.191-229
27 Schilling RSF, Letai AD, Hui SL, Beck GL, Schoenberg JB, Bouhuys A. Lung function, respiratory disease, and smoking in families. Am J Epidemiol 1977; 106:274-83